

STEM COIL MODEL VERIFICATION: A PILOT STUDY IN LATVIA

Andreas Ahrens¹, Jelena Zascerska², Julija Melnikova³,
Anastasija Bikova⁴, Ludmila Aleksejeva⁵, Mihails Zascerskis⁶,
Olga Gukovica⁷, Irina Abjalkiene⁸

¹ Hochschule Wismar University of Applied Sciences Technology Business and Design,
Germany

^{2,4,5,6,7,8} Centre for Education and Innovation Research, Latvia

³ Klaipeda University, Lithuania

Abstract. *STEM COIL (Science, Technology, Engineering, and Mathematics Collaborative Online International Learning) is an emerging research and education area. This research was enabled by the research question: Is the STEM COIL model designed right? The work aim is to verify the STEM COIL model underpinning the evaluation of the pilot study carried out in Latvia. Descriptive study was deployed. Observational method of the descriptive study was carried out in Latvia in April 2024. Collected data were processed via content analysis. The obtained results were interpreted. The novelty of this research is represented by the STEM COIL model verification based on results of the pilot study carried out in Latvia. The findings of the descriptive study reveal that the STEM COIL implementation coincide with the STEM COIL theoretical model. In other words, the elements of the STEM COIL performed their function in the intended way. The analysis of the pilot study carried out in this work allows concluding that the STEM COIL model has been verified as the STEM COIL elements performed the intended function in the course of the implementation of the pilot study carried out in Latvia in April 2024. Consequently, STEM COIL provides opportunities for STEM learners who wish to improve their STEM knowledge, increase their inclusiveness and equity in society in general and STEM education specifically.*
Keywords: *COIL (Collaborative Online International Learning), descriptive study, equity, inclusion, pilot study, STEM (Science, Technology, Engineering, Mathematics) education, model verification.*

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Introduction

Currently, all spheres of our life are being digitized, digitalized, automated, and robotized in order to ease people life. Digitized, digitalized, automated, and robotized gadgets are supposed to make Europe climate neutral, thereby contributing to our sustainable development and greener future (Zascerska, Emet, Usca, & Bikova, 2023).

Leveraging and advancement of these trends of digitisation and digitalisation, automation, as well as robotisation require everyone participation (Zascerska, Emet, Usca, & Bikova, 2023). Everyone - being user or developers of digitized, digitalized, automated, and robotized gadgets – needs to obtain specific knowledge, also known as STEM education. It should be noted that everyone's inclusion in STEM education is crucial (Zascerska, Aleksejeva, Zascerskis, & Abjalkiene, 2022) for reaching the objectives of green and digital transformation. Therefore, STEM education is becoming the linchpin in the educational system of any country.

Conventionally, STEM knowledge in any type of education is exchanged in a face-to-face class (Zascerska et al, 2021). However, the COVID-19 pandemic has motivated mixed class teaching, also known as hyflex (hybrid flexible) class teaching (Aleksejeva, et al, 2021). One of the scenarios of hyflex class teaching was identified to be Collaborative Online International Learning (COIL) (Zascerska et al, 2022). Therefore, STEM COIL classes have

been introduced into education. However, there is a lacuna in STEM COIL model verification.

The present research was enabled by the research question: Is the STEM COIL model designed right? The aim of this work is to verify the STEM COIL model underpinning the evaluation of pilot study carried out in Latvia.

The current work refers to qualitative research. Descriptive study was deployed in this work. Observational method of the descriptive study was carried out in Latvia in April 2024. The collected data were processed via content analysis. The obtained results were interpreted.

The novelty of this research is represented by the STEM COIL model verification based on results of the pilot study carried out in Latvia.

STEM COIL Theoretical Framework

STEM COIL consists of two concepts (STEM COIL, 2021):

1. STEM, and
2. COIL.

STEM acronym was introduced in 2001 (Hallinen, 2024). STEM refers to Science, Technology, Engineering and Mathematics (Zaščerinska, Andreeva, & Aleksejeva, 2015). They can also be defined as educational disciplines (Zascerinska, Aleksejeva, Zascerinskis, & Abjalkiene, 2022). The educational discipline relates to the subject knowledge (Zascerinska, Aleksejeva, Zascerinskis, & Abjalkiene, 2022). Subject knowledge is advanced, exchanged, transmitted, and transferred in the educational process implemented in three logical and sequential phases (Zaščerinska, 2013) as shown in Figure 1.

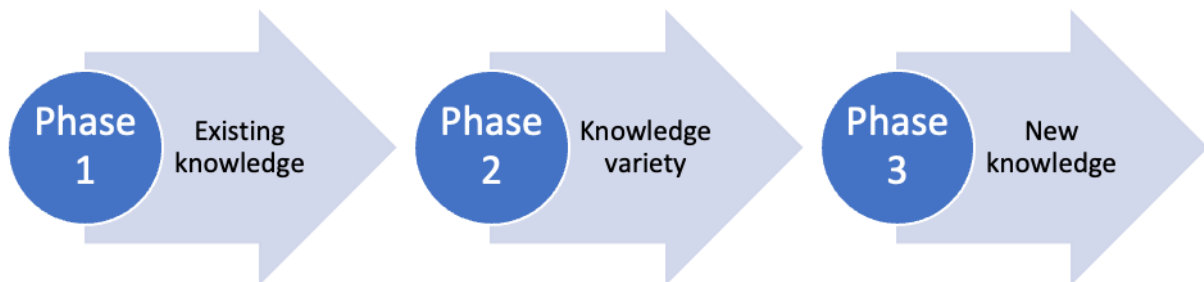


Figure 1 Phases of STEM knowledge exchange in education (the authors)

Conventionally, STEM knowledge in any type of education is exchanged in a face-to-face class (Zascerinska et al, 2021). However, the COVID-19 pandemic has motivated mixed class teaching, also known as hyflex (hybrid flexible) class teaching (Aleksejeva et al, 2021). One of the scenarios of hyflex class teaching was identified to be Collaborative Online International Learning (COIL) (Zascerinska et al, 2022).

It is worth noting that the COIL model appeared in the early 2000s (SUNY COIL, 2024). COIL has been at the forefront of empowering teachers and trainers, learners, programs and institutions to embrace diversity through inclusive teaching and learning focused on equity while connecting through difference (SUNY COIL, 2024). COIL provides a means to (SUNY COIL, 2024):

- Develop intercultural awareness and communicative competencies, cost effectively and at scale;
- Encourage appreciation for diverse backgrounds and perspectives;
- Broaden and strengthen students' understanding of the discipline studied through applied projects and discussions;

- Advance the use of technology tools for collaboration, communication and learning;
- Prepare students to work in a multi-cultural and connected world.

In COIL scenario, students and teachers in different countries are connected for collaborative projects and discussions as part of their coursework (Zascerinska et al, 2022). Table 1 adapted from Zascerinska et al (2022) specifies the COIL scenario.

Table 1 COIL scenario in a hyflex class (the authors)

Scenario	Teacher	Student	Language of instruction
COIL	A couple of teachers from different countries	Students are from at least 2 countries, each of 2 students' groups is in the campus class, these 2 students' groups are connected via the Internet.	An international language is used for both teachers' and students' communication in the COIL class

In 2021, the fusion of STEM and COIL took place (Zascerinska et al, 2022). The new development model received the name STEM COIL (STEM COIL, 2021). Table 2 gives an overview of the STEM COIL model development in a historical perspective.

Table 2 A historical perspective on STEM COIL model development (the authors)

Nr	Phenomenon	Historical period	Reference
1	STEM	2001	Hallinen, 2024
2	COIL	2000s	SUNY COIL, 2024
3	STEM COIL	2021	STEM COIL, 2021

Figure 2 present the STEM COIL model in education (Zascerinska et al, 2022). Relationships between the key elements of the STEM COIL model are demonstrated in Figure 2 as well.

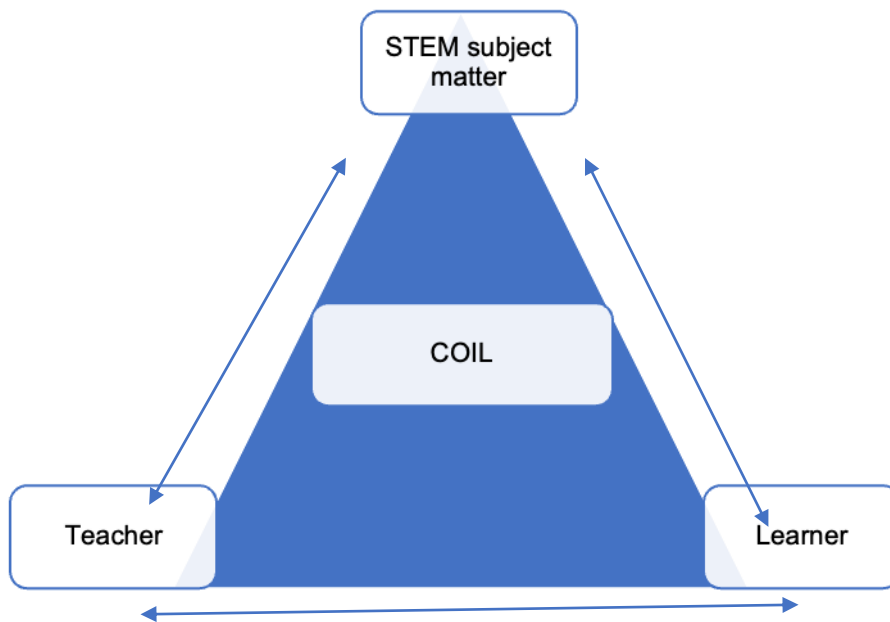


Figure 2 STEM COIL in education (the authors)

Based on the analysis of the STEM COIL model carried out in this work, the key characteristics of STEM COIL are reflected in Table 3.

Table 3 Key Characteristics of STEM COIL implementation (the authors)

Phenomenon	Key characteristics
STEM COIL	STEM knowledge
	Inclusion
	Equity

Table 4 details characteristics of STEM COIL implementation in education.

Table 4 Characteristics of STEM COIL implementation (the authors)

Phenomenon	Key characteristics	A short description	Reference
STEM COIL	STEM knowledge	Use of STEM disciplines	Zascerinska et al, 2022
	Inclusion	A couple of teachers from different countries	Zascerinska et al, 2022
		Students are from at least 2 countries	Zascerinska et al, 2022
		Each of 2 students' groups either in the campus class or online	Zascerinska et al, 2022
	Equity	These 2 students' groups are connected via the Internet	Zascerinska et al, 2022
		An international language is used for both teachers' and students' communication in the COIL class	Zascerinska et al, 2022

STEM COIL is an emerging research and education area. The use of STEM COIL in education intends to increase STEM knowledge, social impact and inclusion.

Methodology of the Research

The study was enabled by the research questions: Is the STEM COIL model designed right?

The purpose of the empirical study was to verify the STEM COIL model via the implementation of the pilot study in Latvia.

Model verification is an important step in model development (Thacker et al, 2004). Verification confirms that all elements of the system perform their intended functions and meet technical (performance and operational context) and interface requirements and constraints (i.e., the product was built right) (Hahn, 2013). In other words, verification is intended to ensure that the model does what it is intended to do (Hillston, 2003). Testing is a method of model verification in engineering, while in social sciences it is called pilot studies (Hahn, 2013).

Model development and verification via analysis of pilot studies refer to qualitative research in this work (Ahrens et al, 2023).

The descriptive study was deployed in this work. Descriptive studies can be also used for verification purposes (Rott, Specht, & Knipping, 2021). Descriptive study takes place in natural settings. No any manipulation within the descriptive study is intended. Conventionally, descriptive study aims at describing a situation for better understanding a

phenomenon. This type of the research was chosen as there exist a lacuna in the verification of the STEM COIL model.

The descriptive study was carried out online on 10 April 2024. About 190 participants took part in this online event. The audience included researchers in STEM, education and other scientific disciplines, higher education students, academic staff of Latvia's higher education institutions, a representative of a regional museum in Norway. The online event was devoted to STEM in Latvia. Four STEM centres in four cities of different regions of Latvia - namely Liepaja, Daugavpils, Ventspils, and Cesis - were presented to the audience.

The method of observation was leveraged for qualitative data collection. Observation serves as an effective method in obtaining qualitative data (Zascerinska, 2013). Observation helps build an adequate picture described from a number of participants' perspectives (Geertz, 1973). A researcher was the participant of the group in which STEM COIL was implemented in Latvia in April 2024. Observation with the participation of a researcher is beneficial (Hargreaves, 1967). This direct participation in the group permits an easy entrance into the social situation by reducing the resistance of the group members; decreases the extent to which the investigator disturbs the 'natural' situation, and allows the investigator to experience and observe the group's norms, values, conflicts and pressures, which (over a long period) cannot be hidden from someone playing an ingroup role (Hargreaves, 1967).

The collected qualitative data were processed via content analysis. The types of content analysis were structuring and summarising analysis (Mayring, 2000) as illustrated in Table 5.

Table 5 Types of content analysis used in the descriptive study (the authors)

Method	Type of the method	A Short description	Reference
Content analysis	Structuring content analysis	Categorising the data in accordance to the previously determined criteria	Budde, 2005
	Summarising content analysis	Reducing the material in such a way that the essential contents are preserved, but a manageable short text is produced	Mayring, 2004

The obtained results were interpreted.

The use of the interpretive paradigm in this study is featured by the researcher's interest in a phenomenon (Zaščerinska, Aleksejeva, Zaščerinskis, Gukovica, & Aleksejeva, 2021) and the researcher's practical interest in the research question (Cohen, Manion, & Morrison, 2003). Interpreter is the researcher who carries out the research or study (Ahrens, Purvinis, Zaščerinska, Micevičienė, & Tautkus, 2018).

Paradigm, in general, indicates movements within social science (Phothongsunan, 2010) in general and social science's studies in particular. Interpretivists use more open-ended research questions (Phothongsunan, 2010). The main focus is on qualitative data (Phothongsunan, 2010) as qualitative data analysis could show slightly recognisable changes in a studied environment. Interpretive studies often use small numbers of participants (Phothongsunan, 2010). This is because the purpose is not to generalise (Phothongsunan, 2010), but to explore the meanings which stem from the interpretation (Zaščerinska, Aleksejeva, Zaščerinskis, Gukovica, & Aleksejeva, 2021). Therefore, interpretation encompasses the analysis of the social construction of the meaningful reality (Zaščerinska, Aleksejeva, Zaščerinskis, Gukovica, & Aleksejeva, 2021).

The studied environment was multicultural:

- On the one hand, participants were from Latvia and Norway, and
- On the other hand, participants from Latvia represented different cultures of four cities in different regions of Latvia - namely Liepaja, Daugavpils, Ventspils, and Cesis.

Therefore, the interpretive method was used in this study aimed at understanding other cultures, from the inside through the use of ethnographic methods such as informal interviewing and participant observation, and establishment of ethically sound relationships (Taylor & Medina, 2013). The interpretive research paradigm corresponds to the nature of humanistic pedagogy (Lūka, 2008). The interpretive paradigm creates an environment for the development of any individual and helps them to develop their potential (Lūka, 2008). The core of this paradigm is human experience, people’s mutual everyday interaction that tends to understand the subjectivity of human experience (Lūka, 2007). The paradigm is aimed at understanding people’s activity, how a certain activity is exposed in a certain environment, time, conditions, i.e., how it is exposed in a certain socio-cultural context (Lūka, 2007). Thus, the interpretive paradigm is oriented towards one’s conscious activity, and it is future oriented (Lūka, 2007).

Research Results

At the event beginning, the audience was addressed by the Minister from the Latvia’s Ministry of Education and Science and, later by the Director of Latvia’s State Education Development Agency. Both of them used Latvian language to deliver their messages.

Afterwards, a representative from a regional museum in Norway described key activities of his institution. After the presentation, a short task related to STEM disciplines was given to the audience. The speaker used English language. Translation into Latvian language was provided by the event organisers. A volunteer, who took part in the short task did not need any translation as she understood the presenter using English.

Then, four STEM centres in four different cities of different regions of Latvia - namely Liepaja, Daugavpils, Ventspils, and Cesis - were presented to the audience. The presentations were given in Latvian.

The content analysis was used to compare the theoretical model of STEM COIL with its testing in natural settings within the event organised in Latvia in April 2024. Table 6 reflects the results of the comparative analysis.

Table 6 Comparative analysis of the theoretical model of STEM COIL and results of its testing (the authors)

Phenomenon	Key characteristics	Short description	Theoretical model YES/NO	Practical implementation YES/NO	Observational notes
STEM COIL	STEM knowledge	Use of STEM disciplines	YES	YES	STEM in Latvia was discussed online in an international group
	Inclusion	A couple of teachers from different countries	YES	YES	A number of teacher higher than two from two or more countries was reached
		Students are from at least 2 countries	YES	NO	Only students from Latvia participated in the event
		Each of 2 students’ groups either in the campus class or	YES	YES	Observation showed that the participants, including teachers

		online			and students, took part in the event online
	Equity	These 2 students' groups are connected via the Internet	YES	YES	All the participants were online via the wire, wireless, or mobile Internet
		An international language is used for both teachers' and students' communication in the COIL class	YES	YES	English as an international language was used for the online communication

The findings of the descriptive study reveal that the STEM COIL implementation coincide with the STEM COIL theoretical model. In other words, the elements of the STEM COIL performed their function in the intended way.

Discussion

STEM COIL is a novel teaching and learning methodology in the field of STEM education.

STEM COIL can be expressed in a variety of such forms as written text, painting, drawing, photograph, verbal, body language and others (Zaščerinska et al, 2016).

The use of an international or any other common language for communication in STEM COIL can be easily facilitated by many contemporary technical tools such as DeepL, Google Translate, and similar exist.

Learners' benefits from STEM COIL are

- STEM knowledge is exchanged via modern online and intercultural tools.
- STEM COIL facilitates the increase in STEM learners' motivation to learn STEM via their online involvement in international STEM education.
- STEM COIL serves to provide STEM learners' equity as COIL connects learners from different countries (with high and low GPD countries, from remote areas, industrial and agricultural regions, developing and developed states, etc). STEM COIL helps learners become aware of STEM education in their own and other countries, thereby building and cementing STEM learners' equity.

Conclusions

The analysis of the pilot study carried out in this work allows concluding that the STEM COIL model has been verified as the STE COIL elements performed the intended function in the course of the implementation of the pilot study carried out in Latvia in April 2024. Consequently, STEM COIL provides opportunities for STEM learners who wish to improve their STEM knowledge, increase their inclusiveness and equity in society in general and STEM education specifically.

The presented research was limited by the available scientific works and empirical analysis of STEM COIL. As STEM COIL is a novel teaching and learning methodology, the available publications on STEM COIL are scarce. Another limiting parameter is that, in the STEM COIL pilot study, students only from Latvia participated. Despite the fact that only students from one country participated, the STEM COIL model was found to be verified.

Another limiting factor was the analysis of only one STEM COIL event organised by one country. If more empirical studies are published, then, other results could be received. The research findings were also limited by the use of only observational method for data collection. Use of online survey could provide the researchers with other results.

In future, the presented theoretical model of STEM COIL can be updated with more and other elements and features. The list of STEM COIL benefits could be re-considered as well. In future, STEM COIL model validation will be implemented. Future empirical studies intend to analyse the implementation of STEM COIL in different educational levels (primary, secondary, higher, adult, etc). Cultural aspects of STEM COIL implementation could be also an interesting research field in future. Comparative studies of STEM COIL implementation could motivate STEM teachers for leveraging COIL in STEM education.

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